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"VIA COLENDI."

THE way of the cultivator is proverbially not easy, even though today the agriculturist can call upon the internal combustion engine to help him in his tasks. It is accordingly disquieting to be told that recent investigations are tending to show that in the past the farmer has done more in the way of cultivation than was necessary or even desirable. Farming is a business, the aim of which is not to grow the largest crop, but the crop that shows the greatest profit, subject of course to the land being treated fairly. This being so, and farming being governed by the law of diminishing returns, it is not difficult to overdo the amount of cultivation that a crop receives, and that this is frequently the case, appears from recent experimental work being carried out in Great Britain.

The problem is not, as a matter of fact, a straightforward one. The farmer must suit his cultivation to the weather, and consequently, his calls for power and labour are very variable. For his power in the past, he has had to depend on his trained animals, while as it is not possible as a rule to recruit much extra labour to deal with emergencies, reliance has largely been placed on a permanent staff. Thus it is that work must frequently be found for man and beast, which is not always fully remunerative, but for which there is no alternative except that of idleness. The farmer, too, takes a proper pride in his work, and wants a share of responsibility for the crops he grows, so that he must always be doing something to assist his crop in its progress and avoid all risk of his fellow-planters regarding him as a slovenly fellow.

With these mixed motives, it is easy to understand how much of the tillage which it has been customary to give to crops in Great Britain would fail to stand strict costings accountancy in the changed conditions brought about by the introduction of the tractor. The tractor, although its interest charges are more than those of the livestock it replaces, has not to be fed during periods of idleness. There is no tendency to keep a bigger or a better machine than one's neighbour for there can be little of the competitive spirit between rival tractor-owners, and one can hardly visualize them being shown in competition at the local show.

The time is ripe then for the investigations which Rothamsted is making into the general question of cultivation, the general trend of which,

as mentioned above, seem to be showing that in all probability the British farmer, who has been generally recognised as a master of his craft, is nevertheless lamentably wasting money in over-cultivation, and this, though his cultivation costs are the heaviest item in his budget. The Rothamsted experimenters are studying the effects of standard operations on the physical texture of the soil by observing the degree to which the soil is disintegrated; and this information obtained, they have gone on to compare such standard operations with newer methods, like rotary tillage. One general conclusion that has been drawn from these experiments is that many of the statements made in textbooks on practical agriculture are unjustified, and that cultivations beyond those needed to keep down weeds and incorporate manures are often a waste of time and money. This has been suspected for sometime in maize cultivation in the States, where in recent years a definite move against the excessive inter-cultivation that was at one time preached, has been made. Proof has been obtained, if proof were needed, of the enormous part that weather plays in producing tilth, and the way in which it takes a hand in all tillage experiments, but there is hope that even with reduced tillage operations, more advantage will be taken of weather operations than in the past. The old idea that tillage could not be done at a greater speed than 2 to 3 miles an hour is being discredited, while rotary tillage offers great possibilities in telescoping various operations now performed singly. It seems to the writer that there are similar instances in tropical agriculture where cultivations and other operations are carried out, although it has never been ascertained whether they actually pay.

No time should be lost in carrying out experiments on these points in the tropics. The question of cultivation is just as important and bulks just as large proportionately in the total cost of production in the tropics as in Great Britain, while the planter in the tropics is bound by as rigid a convention in the practice he adopts, as his brother at home, though that convention possibly has not been built upon such long experience. The standard of peasant cultivation is generally described as being deplorably low, and the first reaction of the trained agriculturist used always to be to take steps to improve it, but it is now clear that this must be done with caution: it is now recognized that every point must be tested and proved by field experiments before advice is given. One complication is afforded by the interaction between soil-cover and denudation which in certain circumstances makes a cover of weeds infinitely preferable to a clean surface. This is, as a matter of fact, being realised in many planting industries where not only have cover-crops replaced clean weeding, but even controlled natural vegetation is also being advocated, and this practice could no doubt be widely extended. Such experiments must be carefully done and must be carried on for a long period, and could therefore only find place at a central institution where the necessary staff and apparatus would be available, and where means could be taken to ensure continuity of policy.

AGRICULTURAL RESEARCH IN INDIA.

The Imperial Council of Agricultural Research was set up as a result of the Royal Commission on Agriculture in India in 1926. One of the conditions laid down was that the Council's activities should be periodically reviewed by some disinterested expert, and in 1936 Sir John Russell was invited to make an extensive tour of the provinces with this end in view, in so far as plant industry was concerned.

Sir John's report* has now been published. The volume is divided into two parts, the first of which describes the type of agriculture, the crops and the factors which make for improvement in their yield, the special difficulties confronting Indian agriculture and the machinery for dealing with them. In the second part of the report, the various research schemes fostered by the Council and in progress throughout the country are described in detail.

Agriculture in India is not merely an industry but also the mode of life of a large part of the population, and in consequence the scope of the Council's activities is of a far-reaching nature. Village improvement is in fact an essential preliminary to any fundamental advance in agriculture. The gulf that separates the experiment stations and the few large-scale farmers from the peasants, who cultivate the largest proportion of the land, needs to be bridged, and this is rendered peculiarly difficult to effect owing to the absence of the educated middle class farmers, who form such an important section of the farming community of the West.

A vast amount of pioneering work has been successfully accomplished by the Council since its formation, and the necessary extension now lies in the co-ordination of theory with practice, that is, work in the field rather than in the laboratory, increased productiveness being always the central problem. The great increase in the area under cash crops such as cotton, sugar cane and tea, compared with that under food crops, is one of the most remarkable features of modern Indian agriculture, and although much progress has been made both in their production and utilization, particularly in the case of sugar cane, greater co-operation with the buyers is desirable. Advances in this direction have already been made in the case of cotton and tea, as each crop has its own research station, which is in touch with the appropriate buyers. Similarly, work on food crops needs to be carried out in association with nutrition experts, and inquiries made into the possibilities of extending dairy

* Report on the Work of the Imperial Council of Agricultural Research in Applied Science to Crop Production in India. (Delhi: Manager of Publications, 1937.)

husbandry and fruit and vegetable growing, if diet is to be raised to a more satisfactory level.

In view of the supreme importance of water supply, the establishment of a separate research institute for the study of irrigation and water relationships between soil and crops is deemed desirable. The proper unification of dry farming schemes is, of course, equally important. Questions concerning soil erosion and alkali trouble might well be dealt with by a soil conservation committee, which could also usefully collect and collate results of manurial trials and soil analyses. Similarly, matters relating to crop planning schemes and insect and fungus pests might be in the hands of a crop production committee, which would provide a convenient central body for co-ordination. Special problems such as locust control, on the other hand, need their own organization, and in spite of the fact that invasions only occur sporadically, a permanent service seems eminently desirable, so that immediate action may be taken when the need arises. The Imperial Agricultural Research Institute recently opened at New Delhi will, no doubt, play a specially important part in the co-ordination of the Council's schemes, and its programme be largely determined by the most pressing problems of the moment. A number of questions to which it could usefully give attention are suggested in the report.

During his tour, Sir John Russell visited more than forty experiment stations and inspected nearly ninety research schemes, in most cases discussing the work with the individual in charge. The posts under the Council's schemes are of temporary nature only and a plea is made for the provision of a number of permanent appointments, to be filled gradually by selected investigators of proved ability. By this means, specially experienced men would be available to deal with difficult problems at the various stations, where local resources were inadequate. Such a scheme would inevitably necessitate an increase in the financial grant made to the Council, but the return in enhanced efficiency would seem to justify this.

Much of the research in agricultural science in India is not so widely known as it deserves to be, due largely to the practice of publishing results in a number of small communications. The preparation of a series of monographs by competent persons is suggested, setting forth the results obtained by Indian workers and pointing out how they differ from those obtained elsewhere. Such publications would greatly raise the prestige of Indian research work and also prove of value to teachers and research workers throughout India itself.—(*Nature*, Vol. 142, No. 3604, pp. 964-65, 1938.)

THE CASHEW (*ANACARDIUM OCCIDENTALE*).

During very recent years the cashew has been creating a new interest, chiefly because of the nut which is finding its way into commerce. This tree is native to Brazil and possibly other parts of tropical America. It certainly became widespread on this continent and the West Indies at a very early date and for centuries past it has been growing in warm regions of the Eastern hemisphere also. By the native people of all of these countries, it has been prized for the fleshy portion of its fruit and for the seed which is very curiously placed outside of the flesh or, in common parlance, the "nut" which grows on the outside of the "fruit". As a fruit, the cashew is used in many ways in the countries where it is grown, including dessert, fruit-punch and an alcoholic drink. The fruit is very perishable and cannot be shipped long distances but finds its way to local markets in considerable quantities. It is the seed or nut, however, which in recent years has been bringing the cashew into prominence. The cashew nut has always been appreciated in the countries where the tree grows but it is only recently that it has found its way into world commerce. This new development appears to have been due largely to the discovery of processes of packing by which the nuts can be transported to any country without deterioration or insect attack. These nuts are now packed by a patented process in tight containers from which the air is exhausted and replaced by gases, said to be chiefly carbonic acid, in which they are perfectly preserved. Information received from the Bureau of Foreign and Domestic Commerce of the United States reveals the fact that 10,262,916 pounds of cashew nuts were imported into the United States in the year 1931. These were entered at a value of $2,052,240 which is intended to represent their market value in the principal markets of the country from which exported, including the cost of containers or coverings and all expenses incident to placing the merchandise in condition ready for shipment to the United States In 1932, the imports were slightly under 9,800,000 pounds which represents a very small shrinkage compared with the general falling off in trade in that year of general business depression.

It is worthy of note that nearly the entire importation comes from British India and not from its home in tropical America. Considering the fact that the cashew grows almost as a weed in Panama and yields abundantly even in rather poor soils, it would appear that attention should be given to the possibilities of developing a cashew industry here much nearer to the market. To do this it would be necessary to interest the importing companies in stimulating trade and production here. The climate, the soil, the proximity to market and the facilities for shipping are all in favour of such an industry.

The Canal Zone Experiment Gardens have introduced several varieties of cashew of unusual size and appearance all of which are doing well and yielding abundantly. They are now in correspondence with Brazil in an effort to get some of the best varieties from that country which is believed to be the home of this fruit and which probably makes a wider use of it than any other part of the Western hemisphere.—(*Annual Reports of the Canal Zone Experiment Gardens*, 1933 & 1934, pp. 11–12, 1933.)

RECENT BOTANICAL RESEARCHES IN CACAO.*

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A Review of botanical investigations of cacao must begin with a definition of the material with which it deals, because much of the work to be mentioned has been done on a small section of the crop. Even within that section, research has scarcely proceeded beyond the stage of defining the lines along which knowledge is to be sought. A little straightforward selection from a mixed population, some progress in the technique of propagation, and a few rays of light on factors limiting yield are the main points to be noted. These, however, put us in a position to appreciate many horticultural problems that are bound to arise in the near future, and some discussion of them may be included to show the trend of improvement in one of the most important tree crops of the tropics.

The Material for Research.

Various species and varieties of the genus *Theobroma* seem to have been utilized by the indigenous peoples of America, from Mexico to Peru, before the discovery of the continent by Europeans. The 'bean' was highly prized, and it is only reasonable to suppose that from very early times the natural distribution of varieties was extended by the agency of man. All races of cultivated cacao intercross readily, so far as is known, and whether originated or merely facilitated by human agency, interspecific mixture took place long ago. In some districts hybridization has obscured origins, whilst in others local races remain unmixed and specifically pure.

The number of species concerned cannot be stated, but following Pittier (1) we may recognize two of major importance. The first is *Theobroma Cacao* L., a name commonly applied to all cacao, but *sensu stricto* confined to one constituent only, that known to commerce when grown in a pure state as 'Venezuelan Criollo'. The pods of this species are long, distinctly pointed, deeply furrowed longitudinally, and warty, their colour being commonly dark red, sometimes yellow. The 'beans' tend to a cylindrical shape, rounded at the ends, and the cotyledons of the embryo within are white (perhaps in some varieties pinkish, but never purple) in colour.

Th. Cacao is nowhere known with certainty to occur in a truly indigenous state, but its centre of origin may have been in central America, with a natural range extending down through Colombia into western Venezuela. From western Venezuela it first became known and recognized as a commercial cacao, and it can still be found there in cultivation in a pure state, though on a diminishing scale. Introduced to Ceylon about 1834, it became famous as the 'Old Red Cacao' of that island, and it was also introduced to Java, where it built up a reputation as 'Java Criollo', and to Madagascar and Samoa. Its product has always been accepted as the highest in quality of all commercial cacaos, but the tree itself has the general reputation of being delicate. Some truth in that reputation is indicated by the decline of Criollo cacaos from supplying the bulk of the world's requirements to the position of almost negligible contributors.

The other commercial species is *Th. leiocarpa* Bern. Its pods are oval, without distinct point, only shallowly furrowed, smooth, and commonly (perhaps always) yellow. The 'beans' tend to be lozenge-shaped and are distinctly flattened, and the cotyledons within are dark purple. This species has been found in an almost unquestionably indigenous condition in Dutch Guiana (2), and probably has a wide natural range in the Amazon and Orinoco basins. This, in an unhybridized condition, appears to be the commercial cacao of Brazil and of West Africa, and if that assumption is correct it accounts for some 82 per cent. of the present world crop. The quality of its product is low, but the tree is hardy and to that fact doubtless owes much, though not necessarily all, of its rapid rise in commercial importance.

Either by natural overlapping of ranges or by the agency of man, these two distinct species met long ago in eastern Venezuela, where by extensive and long-continued hybridization they lost their identities and gave rise to a tree population that is most conveniently described as the 'Trinitario mixture'. This is an astonishingly heterogenous assemblage and defies accurate classification, though many writers have made confusion worse confounded by attempting to define 'varieties' within it. It contains individuals of the lowest possible quality alongside others only just short of the highest, but as a population it combines some of the quality inherent in *Th. Cacao* with some of the vigour inherent in *Th. leiocarpa*. Occasional individuals combine a very high degree of both, showing that the genes concerned are not necessarily antagonistic.

Over most of Venezuela, in Trinidad, in Ceylon, and in Java, introduced individuals from this mixture have supplanted the Criollo of earlier introduction by virtue of their greater hardiness and adaptability to conditions. In so doing they have become further hybridized with the older populations, so that although the cacaos of all these countries, together with those of Costa Rica and Grenada, must now be classed as Trinitario, the average quality of the mixture varies from country to country according to the extent of the Criollo contribution. Taking them all together,

* Reproduced from *The Empire Journal of Experimental Agriculture*, Vol. VI, No. 23, by the kind permission of the Clarendon Press.

these hybrid cacaos at present represent about 15 per cent. of the world's crop, that is to say, the bulk of that proportion which is classified as 'fine' cacao, and commands a quality premium over the unhybridized *leiocarpa* product. The small remainder is made up of the remnants of pure Criollo and the 'Cacao Nacional' of Ecuador.

It is probably as much by chance as by merit that the commercial cacaos of to-day have practically all been derived from two sources, one in Brazil (*Th. leiocarpa*) and one in Venezuela (the Trinitario mixture). The cacaos of Peru, Ecuador, Colombia, and the central American countries from Nicaragua to Mexico are virtually unstudied botanically, but we have some evidence of genetically distinct material in those countries. The 'Cacao Nacional' of Ecuador, for example, cannot be referred to either *Th. Cacao* or *Th. leiocarpa* with any confidence, and may prove on study to be a distinct species. It has at least very distinct varietal characteristics, and according to reports is much too uniform to be a mixture like Trinitario. In 'Nicaraguan Criollo' we have another high-quality cacao, which is probably related at least in part to *Th. pentagona* Bern. Only extensive collection in the remoter parts of the distributional range of *Theobroma* can now determine the number of genetically distinct types that may be at the disposal of growers and breeders of cacao in the future. At the present time an attempt is being made to find immunity or resistance to Witches' Broom Disease among some of the hitherto neglected local cacaos, and it is undoubtedly among them that we shall increasingly have to look for the means to make cacao easier and more profitable to grow.

For the present it is Trinitario cacao, especially as represented in Trinidad, that has received the most detailed botanical study, and of the two groups available for immediate improvement this is undoubtedly the more promising. The scope for improvement in *Th. leiocarpa* is limited by its narrow specific origin and consequently narrow range of variability. Possibilities of improvement by selection in West African cacao, for example, certainly exist, but sooner or later the limits of the pure species must be reached. On the quality side, in particular, they are likely to be reached rather quickly. At this point, if we are to judge from the evolution of other crops, the introduction of genes from another species will become desirable. In Trinitario cacao that introduction has been made already, and a widened range of variation is ready for selection of superior types adaptable to various sets of conditions.

Selection.

A genetic survey carried out between 1930 and 1932 by Pound (3) first gave statistical precision to our knowledge of variation in Trinidad cacao. After determination of sampling constants, the mean values of pod dimensions for 950 trees, distributed in twelve blocks on good estates in various parts of the island, were found to be as given in Table I. Individuals falling outside the given limits can be found, but they are rare, and the figures are fairly representative of the population.

Table I.—Mean Values of Pod Measurements.

Dimension.	Lower limit.	Upper limit.	Mode.
Length ...	10.5 cm.	23.5 cm.	16.0 cm.
Diameter ...	6.1 cm.	10.6 cm.	8.0 cm.
Ratio (shape) ...	1.3	2.7	1.95
Shell thickness ...	0.8 cm.	2.4 cm.	1.4 cm.
No. beans ...	15	45	34.5
Pods to the pound	6	22	10.5
Weight of a single bean ...	1.1 gm.	5.6 gm.	3.2 gm.

On these results a selection programme was planned, directed primarily at increasing yield, with quality neither neglected nor over-stressed. In view of the wide variation in 'pod value', expressed by the finding that six pods from one tree may yield as much cacao as 22 from another, the obvious course was to make a first selection on pod value and to reselect on bearing qualities (*i.e.* number of pods per tree), with a correction for size of tree and area of ground occupied. In this way, by the end of 1935, 100 trees had been selected in different soils and locations, of various types and qualities, each actually yielding cacao at a rate of not less than one ton (cured beans) per acre. Details of procedure have been published by Pound (4) and by Cheesman and Pound (5).

In the course of the survey and the initial stages of selection, some interesting and highly important facts came to light. In the first place it appeared that pods containing a large amount of cacao usually have individually heavy beans. In other words the increased weight of cacao is due to increased size of beans rather than to increased number. Inasmuch as bean size is one component of quality, this finding indicated that the method of selection for yield involved to some extent an automatic selection for quality. Nevertheless it was still proposed to lower the yield-standard in the case of trees of outstanding quality, until it was further found that certain trees selected primarily for quality were passing easily the standard set for yield. In the end there was found scarcely any tendency among the selected trees for yield and quality to be antagonistic, and this is perhaps the most encouraging conclusion that has yet emerged from the work on selection.

Propagation.

For the full exploitation of the results of selection in a tree crop, the use of vegetative propagation may be regarded as essential, and for this reason studies of propagation methods have gone hand in hand with the selection programme. In this connexion, however, it is necessary to distinguish

between the immediate objects of research and what have been called its 'long-range' aims. To view both in true perspective we have first to recognize that cacao has never yet been grown commercially by vegetative propagation except on an insignificant scale. It is true that such commercial experiments as have been made do not preclude the feasibility of the process, where reasonably intensive methods can be applied. On the other hand, the bulk of the world's cacao is grown by methods anything but intensive, and no immediate revolution in the industry is to be expected. Current discussions of the relative merits of buddings and clonal seed in rubber cultivation serve to show that the arguments are not all on one side when the choice has to be made between vegetative and seedling propagation in tropical crops.

Research in propagation is therefore not aimed at immediate change in planting methods, but there remain many reasons for its prosecution. Perhaps foremost is the necessity for uniform material to facilitate the crop physiologist and other investigators in planning and carrying out precise experiments. Then there is the advantage of clonal plantings for cheap control of pollination where selected seed of known parentage is to be supplied. There is—by no means of least importance—the demand of the planter who can use intensive methods, and is prepared to do so, for the best planting-material available. There are dozens of questions in cacao-cultivation which can be answered only by horticultural experiments based on vegetative propagation.

The history of asexual propagation of cacao, which goes back 40 years, has been summarized by Cheesman (6), together with an account of the horticultural problems involved. Recent work has been concentrated on propagation of selected trees on their own roots by the striking of cuttings, and a simple but efficient technique has been worked out (7). Some of the first cuttings rooted are now four years old, and their growth has been quite satisfactory, both above ground and below.

A field experiment is now being planted to compare trees raised from cuttings with those propagated by budding the same clones on seedling-root-stocks. At the same time a dozen specially robust and heavy bearing trees have been selected and propagated for use as clonal stocks, and budding on these will be included in further tests. Such comparisons will serve the longer-range objects of research, and for more immediate purposes steps are being taken to compare cuttings with seedlings from the same trees.

The most immediate purpose of all in this clonal multiplication, however, is the testing and comparison of the selected trees, as it is on their clonal progenies that the soundness of the selection principles must be proved or disproved. Not only in yield, but in detailed behaviour, in habit, earliness, disease-resistance, and other respects the clones may be expected to differ significantly, and the differences may perhaps be turned to profit.

Factors Influencing Fruitfulness.

Appreciable progress towards an understanding of the factors influencing yield in Trinitario cacao has been made by the discovery of widespread self-incompatibility in the tree population. First noticed by Pound (8), this phenomenon has been further studied by Voelcker (9), with the surprising result that a large number of the trees specially selected for their high yields are found to be almost sterile with their own pollen. Others, however, are apparently fully self-fertile.

On the one hand this discovery may help to explain the very wide fluctuations in yield from tree to tree, and the high proportion of poor bearers in the population. It may also be one cause of the disappointing results of selection in the past, when seedling progenies have been used, since it is apparently possible for a heavy bearer to set all its crop by cross-fertilization. On the other hand it opens up some new problems and throws fresh emphasis on some old ones. The agent of natural cross-pollination in the field has never yet been identified, and it is now clearly necessary to find out more about it. If it is an insect, fluctuating seasonably in abundance, it may have a great influence on the seasonal distribution of the crop, and this in its turn will be likely to affect final yield.

If vegetative propagation is not used commercially, the importance of controlling the parentage of the seed supply on both sides is emphasized, and if vegetative propagation is to be used there are obvious dangers in planting monoclone blocks without exhaustive tests of compatibility.

For immediate purposes it is evidently advisable to concentrate on self-compatible clones, but as some self-incompatible trees are very high yielders of superior cacao, it does not seem advisable to drop them from selection lists without further trials. They may have horticultural characters making it profitable to interplant their clonal progenies with suitable pollinators. So far it has been found that pollen from a self-compatible tree sets fruit on a self-incompatible, but that pollen from another self-incompatible does not. Further investigation may reveal cross compatibilities among the self-incompatibles.

Not the least interesting point about self-incompatibility is that it does not seem to occur in West Africa. Whether it has been introduced into Trinitario by the Criollo parent, or whether it is a direct consequence of hybridity, absent in both the pure species, remains to be determined when we have fuller facilities for studying the Criollos.

Horticultural Outlook.

From the horticultural point of view the significance of recent cacao research is that it has taken the first steps in substituting for a mixed population a number of selected lines or clones which can be studied intensively. The major issues between seedling lines and clones, between selfing and crossing of selections if seed is to be

used, and between 'own roots' and foreign root-stocks if vegetative propagation is to be used, all remain to be worked out, along with many lesser problems. Analogy with other tree crops, having a longer history of research behind them, suggests not only that these steps are essential to progress, but that progress can scarcely fail to follow when they have been taken.

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MISCELLANEOUS NOTES.

Studies in Relation to Fertilizer Requirements of Citrus Trees in the Western Transvaal.—*By W. J. Allwright.*

After a summary of the commonly expected effects of nitrogen, potash and phosphate on citrus trees, and a survey of manurial and irrigational methods used in the western Transvaal, experiments, undertaken simultaneously in three commercial orchards on Navels, Valencias and seedlings are described. A uniformity trial was run at the same time to guide future experimenters, and showed the best size of plot to be six or eight trees. All the trees were on rough lemon stocks and were growing on a quartzite soil inherently deficient in all three manurial elements. The Navel orchard was irrigated on the furrow system in 1932, modified flooding 1933 and complete basin 1934-5. The Valencias had basin irrigation over half the orchard in 1932 which was gradually extended till it covered the whole area in 1934. This method was used for the seedlings the whole time. Four randomised blocks were made in each case, with plots corresponding to all eight combinations of no fertilizer, nitrogen, potash and phosphate, together with extra plots for sulphate of ammonia plus bone meal and plus cattle manure in the case of the Navels and Valencias. Eight trees were allotted to each plot, except for the seedlings, where six trees per plot were used. Single rows of guard trees separated the plots. All the statistical working is clearly shown, the methods used being the analyses of variance and covariance. Sulphate of ammonia and cattle manure gave the greatest increase in yield. The size of fruit of Navels was decreased by nitrogen and potash, but Valencias were unaffected. Juice was decreased in all cases by sulphate of ammonia alone, and increased by superphosphate. Potash increased the juice of seedlings. Sulphate of ammonia and cattle manure made less difference than ammonia alone. Generally speaking superphosphate diminished soluble acid content, and nitrogen increased it. Potash increased it in all cases. The soluble solids-acid ratio was consistently raised by superphosphate, and lowered by sulphate of ammonia. In general the addition of cattle manure to sulphate of ammonia lessened its effect on the ratio, which was mostly decreased by potash. Observers considered that superphosphate alone gave the best fruit, and sulphate of ammonia the worst, for, though the colour was increased, the rind was much thicker. Nitrogen darkened and improved the colour of the foliage, and prevented the formation of dead wood. Cattle manure added to sulphate of ammonia increased its value. The dimensions of the trees and the soluble solids content of their fruit were not significantly changed by any manurial treatment, but all the above observations varied significantly with the years. A list of other similar experiments is included, and their results compared with those found in the western Transvaal.—(*Imp. Bur. of Hort. and Plantation Crops*, Vol. VIII, No. 1, Abs. 179, p. 54, 1938.)

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"The Miraculous Fruit."

One of the most remarkable and interesting of the plants that have come under observation during the year is the "Miraculous Fruit," *Synsepalum dulcificum* (F.P.I. 75, 283). This tropical African shrub of upright and rather narrow habit, with dark green foliage belongs to the family *Sapotaceae* and produces small red fruits, oblong to oval in shape, about three-quarters of an inch long and three-eighths of an inch in diameter. This strange fruit makes sour things taste sweet. It is rather pleasant to the taste but after it is kept in the mouth for a few minutes and is partly masticated, the most acid lemon or lime tastes as sweet and pleasant as a well-sweetened fruit punch. The cause of this remarkable reaction which has given rise to the name "miraculous" fruit is not well understood nor has it been determined how long the effect will last. No uncomfortable effects have been observed. The plant is worthy of further study and it is possible that it may be found to be of some economic importance.—(*Annual Reports of the Canal Zone Experiment Gardens*, 1933 and 1934. pp, 20, 1938.)

FURTHER STUDIES IN TROPICAL LAND TENURE.

By H. M. Leake.

(*Continued from Tropical Agriculture*, Vol. XV, No. 12, p. 275.)

VI. FIJI.

The Colony of Fiji is composed of a group of a large number of islands of which two, Viti Levu and Vanua Levu, are the most important. The total population in 1935 was estimated at somewhat over 200,000 with a density of some 29 per sq. mile. This figure of density, however, has little value from the agricultural aspect since much of the land is mountainous and the agricultural land is limited. Of more importance is the nature of the population. Approximately 49 per cent. is native Fijians and 43 per cent. Indians introduced under the indenture system, which ceased in 1917, and become permanent residents.

The prosperity of Fiji is bound up with the production of sugar. Sugar had figured prominently in Fiji even before the cession to Britain. Originally grown on a number of independent plantations, it now forms a monopoly of the Colonial Sugar Refining Company and the story of the fusion of the plantations to form this monopoly has already been told. Production in the early days of the C.S.R. was on a plantation basis with a paid labour force recruited from India. With the cessation of the indenture system under which this labour was recruited, a shortage of labour arose for, not only was the supply cut off, but the existing supply rapidly dwindled since the Indian, freed from his indentures, either returned to India or preferred to take up land from the native Fijian. There, thus, arose two problems in the Islands; the problem of the production of sugar by the C.S.R. on its own lands in the absence of an adequate labour force and the problem of the relationship between the native Fijian land owner and the Indian peasant settler.

The first of these problems was solved by the C.S.R. by a far-sighted measure. The lands owned by the Company were divided up into peasant family holdings which were leased to the freed Indian and, concurrently, a technical service was organized the function of which was to control the system of advances made by the Company for building houses, equipment and cattle, to supervise cultivation and the rotational harvesting of the sugar crop and, generally, to act as guide, philosopher and friend of the tenant. The system has now been in operation sufficiently long to be pronounced a success and the whole of the Company's estates, with the exception of a relatively small area retained for experimental and demonstration purposes, are now so divided up. From the purely business aspect the system has yielded a supply of cane at a price which has enabled the Company to compete in the world's market throughout the recent depressed conditions. From the aspect of the tenant the conditions are also satisfying for, though the price paid for cane fell from 16*s*. 8*d*. to 15*s*. 8*d*. per ton in 1931 and reached 14*s*. 3*d*. in 1935, these prices compare favourably with those paid in the West Indies. Further, the price is not the sole measure of the peasant's gain. Under the supervisory system the peasant yields of cane approximate, as they do not in the West Indies, to those of the plantation. On the more human side, though open to criticism on certain points as is only natural seeing that it arose to meet an economic situation, the system has gone far to establish a contented and advancing peasant community. Evidence of this latter fact is furnished by that usually severe critic, C. F. Andrews.*

The entry of the Indian into the lease of land owned by Fijians raises a problem of a different nature. It is here a question of the protection of native rights and a matter for Government as trustee. In 1912 direct sale of native land except to Government was prohibited and land became available only on leasehold, the terms being arranged by Government and conforming to those for the lease of Crown Lands. In the case of agricultural land, which concerned the Indian settler, the lease is for 21 years renewable at intervals of 21 years with reassessment of permanent and unexhausted improvements or, if the lease is cancelled, with compensation for these.

The communal system of tenure under which the native land is held, however, renders leasing, even under the above control, none too easy. After the prospective tenant has obtained the consent of the individual holder and lodged his application with the District Commissioner, the consent of the tribal authority has to be obtained through the Native Lands Commission. Both at the preliminary entry and, again, on renewal, opportunity exists for what Andrews, possibly with undue harshness, terms blackmail. Stockdale, in less emphatic language, has drawn attention to the same point.†

There is here the problem of balancing the divergent interests of two parties and it is no easy one, nor, probably, is it capable of any final solution, for there exists no constant ratio between the desire of the one party to possess and of the other party to lease. It is a position which finds its counterpart in northern India where the changing relation between the tenants' demand for land and the landlords' (zemindars') desire to lease is reflected in the tenancy legislation particularly of the United Provinces. At the present time the desire to secure land is dominant

* India and the Pacific, 1937.

† Rept. on Visit to Fiji, C.A.C. 865, 1938.

in Fiji and the issue will take practical form in the near future for, during the next few years, an increasing number of leases will fall due for revision. That the matter is not being neglected entirely is apparent from the number of amendments to the Native Lands Ordinance (1 of 1905) which have recently been passed. Such are Ordinance 27 of 1932 which upholds a lease when other than the registered holder of the title is proved to be the real possessor, Ordinance 34 of 1933 which lays down the method of assessing the permanent and unexhausted improvements, and Ordinance 14 of 1937 which deals with questions concerning the outgoing tenant. If these are the main problems, they are not the only ones raised by the leasing of native land by Indians. There are questions of Indian sub-tenures and irregular holdings which have yet to be answered.

Meanwhile the Indian is not alone in his desire for land. The Fijian is also being induced to take up agriculture and with no little success, as is shown by the fact that 75 per cent. of the bananas produced are raised by Fijians.* This movement is fostered officially by a system of demonstration farms around which are settled Fijians who are exempt from the communal duties imposed under the native regulations. But this matter, too, is not simple. The move towards independence shown by the Fijian when he turns to agriculture and fostered by the above action of Government and the Colonial Refining Company, is in direct opposition to native custom which is strongly communal. The Fijian is becoming increasingly aware of the limitations imposed on him by custom, especially the periodic liability to communal duties, and is coming to resent these. His growing aspiration for individual expression can only be met by a changed attitude towards the land and the question of tenure is, according to Stockdale, the most outstanding one requiring urgent settlement.†

Government action here takes the form of advances which are made for the purchase of implements, while the sale of produce is also organized by the Department of Agriculture. In this connection the Native Lands (Occupation) Ordinance (35 of 1933) established rules for the issue of non-transferable leases of Native Lands to Fijians for periods of ten years. This move on the part of Fijians towards agricultural pursuits has received further encouragement by the throwing open of several areas under the control of the C.S.R. to Fijians with such satisfactory results that the scheme has become firmly established.‡

Sugar, as stated already dominates the situation in Fiji and too great a dependence on a single crop is unsound, especially if it encroaches on the food supply of the people. With a large Indian population, rice is an important item of food and the encouragement of its cultivation and the development of a high quality rice have been stimulated by the erection of an officially controlled rice mill which was, however, closed down in 1936 as it had achieved its purpose. As the result, a permanent paddy and milling industry, sufficient to render the Colony self-supporting in the matter of rice, has been established.

A secondary crop of considerable importance is the banana, the major market for which is New Zealand. The export of bananas, formerly controlled under the Fruit Export Ordinance (6 of 1906), is now controlled by the Fruit Export and Marketing (Amendment) Ordinance (26 of 1933), an Ordinance which not merely changed the title of the earlier Ordinance but established a closer control by taking power to limit the agents to whom fruit might be consigned. Under it supervision is maintained over cultivation, while licensed buyers for prescribed areas are required to purchase all fruit of good quality at a price fixed by a Board representative of Government, buyers and growers. In 1932, owing to the quota system introduced into New Zealand, the Fruit Export (Amendment) Ordinance (23 of 1932) was passed giving the Governor power to restrict or prohibit the export of bananas and to purchase the maximum quantity exportable during any specified period from any area or by any holder of a licence. At the same time the Australian and Canadian markets are being explored.

Pineapples, as an additional cash crop, have passed through a chequered career. The several companies established to handle the produce raised by peasants under a contract by which the Company provided planting material and advice, had closed down by 1933. It is of interest, however, to note that the C.S.R. has recently resuscitated the industry thus, at one and the same time, widening the bases of its own and the Colony's production.

VII.—MAURITIUS.

Mauritius is a small island, 720 sq. miles in area, lying in the Indian Ocean. Relatively speaking, it is heavily populated with some 400,000 persons giving a density of approximately 545 per sq. mile. Of this population some 268,000 is Indian, immigrants or the descendants of immigrants. The island exists in a state of what may be termed economic disequilibrium for no less than 148,000 of the 174,000 cultivated acres are under sugar-cane and the population is dependent to the extent of over 80 per cent. on imports of essential food stuffs. Since these have to be paid for by exports of which sugar forms approximately 97 per cent. of the total value and thus dominates to the practical exclusion of all else, it is sugar that controls the economic life of the Colony and its problems may be discussed in terms of sugar. The steady fall in the price of sugar from Rs. 19.15 per 50 kilos. in 1923-24 to Rs. 5.46 in 1936-37 has, therefore, hit the island very severely. It is a fall which took place in spite of the preferential duties imposed by the British Government. The

* Colonial Repts. Annual, 1604, 1931.
† *loc cit.*
‡ Colonial Repts. Annual, 1689, 1933.

arithmetical relation between these two figures is not, fortunately, the true measure of the island's economic position; there has been a corresponding fall in other commodities on which the industry is dependent, notably a fall of some 36 per cent. in the price of fertilizers, and the industry itself has been relieved by Government loans, by cancellation of the export duties amounting to Re. 1.30 per 100 kilos, and by reductions of storage and dock charges, though these latter, considered from the point of view of the island as a whole, partake of the nature of robbing Peter to pay Paul. A further appreciable factor affecting favourably the island as a whole is the corresponding fall in the price of essential food stuffs. Food and drink were imported to the value of over Rs. 23.5 million in 1926 while a slightly larger quantity in 1935 cost under Rs. 13 million. There being no reason to suppose that the non-labouring classes have changed their drinking habits materially in the interval, this implies a very definite rise in the real value of wages offset, however, by a reduction of wages in 1931 corresponding to the decrease in the cost of living.

There is, further, an uncertain climatic factor affecting the industry. The island is subjected to the periodic visits of drought and cyclones. In the 12 years 1926-1937 the average production was 221,400 tons with a maximum in 1937 of 312,000 tons. During the period the island has been subjected to two cyclones, in 1926 when production fell to 198,500 tons and in 1931 when it fell to 164,000 tons, and two droughts, in 1930 with a barely average production, and in 1934 when only 178,800 tons were produced.* More than elsewhere, perhaps, provision has to be made to meet these contingencies.

This is the economic setting as it affects land tenure. The basis of the system has already been described and has not been altered. Inevitably the subject has to be discussed in relation to the dominant sugar industry. This industry arose in an unpopulated island on a basis of relatively small estates through the energy of French immigrants. Labour in those early days was supplied under a system of slavery. The first disturbing element in this organization arose through the introduction of the vacuum pan and large scale central. There has, in consequence, been a gradual reduction in the number of estates carrying a factory. From 171 factories in 1875 the number fell to 65 in 1909 and at the present time there are only 38. Even these are relatively small as compared with modern centrals, averaging as they do under 9,000 tons annual output.

The second disturbing factor arose through labour. Imported in the early days as slaves, it was later supplied from India under an indenture system when emancipation created difficulties in supply. Though the Indian, as elsewhere, has preferred to settle on his own land when freed from his indentures, he has remained largely a labourer, supplementing his income from crops raised on his own land by working for the estates. The two processes have made the position of the smaller plantation owner, growing cane with hired labour and selling to the factories, precarious, and there has been a growing tendency for the estates without factories to disappear, the land being broken up into small holdings which are sold on a deferred payment system to small planters as they are called—the counterpart of the cane farmer of the West Indies. The present situation, the result of this progressive change, is that there are 38 estates with factories, about 35 without, and some 20,000 small planters defined as suppliers of under 1,000 tons of cane.* The dividing line between the estate without factory and the holding of the small planter is, naturally, not sharply defined. The area held by Indians, for practical purposes synonymous with the latter, is 56,025 acres, approximately 43 per cent. of the area under cane. A caution, however, is required with regard to these figures. The area held by Indians or small planters is not the same as the area of cane planted by these. A completely concordant series of figures has not been traced, but the general trend is clear.

These progressive changes are accompanied by certain reactions. The small planter, though as a group he is supplemented by a certain number of tenants of the larger estates which have leased inferior and outlying areas in small holdings, has become established as an independent unit. Beyond regarding the factory as a market for his cane, he looks to it to finance him over the crop season or to a body of entrepreneurs or sirdars, a group of intermediaries who contract on the one hand with the factory to supply cane and to the small planter on the other to meet their contracts. The consequence of the system is that the small planter, subjected to no technical guidance, raises a crop yield far below that of the estate. Again with a repetition of the caution respecting the adequacy of the figures, it is found that the small planter, cultivating some 43 per cent. of the area under cane, supplies only 34 per cent. of the crop delivered to the factory, the estates without factories supplying some 53 per cent. and the estates with factories 13 per cent. These figures may be compared with those presented to the Royal Commission of 1909 which showed 30 per cent. of the total cultivated area under cane as cultivated by small planters while cane supplied by these to the factories formed only 22 per cent. of the total crop. These figures, though they cannot be taken as a measure of the relative efficiencies of plantation and small planters' cultivation, since it is the land of poorer quality which is first disposed of, supply very definite evidence of defective cultivation by the latter.

The parlous state of the industry has been met by the issue of a series of loans backed by Government. From loans issued before 1929 the

* H. Lincoln.—The Past and Present Position of the Mauritius Sugar Industry, Pamphlet, 1938.

* Report, Commission of Enquiry into Unrest on Sugar Estates in Mauritius, 1937, Mauritius, 1938.

amount outstanding at the end of 1937 was Rs. 4,321,744. In 1929 two Sugar Industry Loans were issued (Ordinances 13 and 14 of 1929), one a sterling loan for £204,603 of which £204,104 or Rs. 2,721,389 was outstanding and one for Rs. 3,400,000 all of which was outstanding at the end of 1937. Again, in 1930 (Ordinance 24 of 1930) advances were made from the Improvement and Development Fund of which Rs. 3,036,481 were outstanding at that date. The total indebtedness of the industry is, thus, Rs. 13,479,614 the interest on which constitutes a heavy overhead charge on the industry. The finance of the industry has also been fostered by the establishment of an agricultural bank under the Agricultural Bank Ordinance (1 of 1936) financed by Government loan for the purpose of making long term loans.

A further step in the centralization of the industry was effected with the establishment of the Mauritius Sugar Syndicate. A Sugar Sales Committee for the marketing of sugar was appointed by the Government in 1918 for the purpose of facilitating and emphasizing the diversion of the output to the United Kingdom as a war measure. Prior to that time the principal market was India, a market which has since been lost since India has become self-sufficient. The Syndicate was established in 1919 for the purpose of marketing the 1919-20 crop as successor to the Sales Committee but its life has been extended under a series of Ordinances (7 of 1932), with the Mauritius Sugar Syndicate (Extension of Powers) Ordinance (22 of 1932) and the 1936 Mauritius Sugar Syndicate Ordinance, the periods of extension ranging from three to five years.

The Syndicate is a corporate body which sells the sugar of its members after classification, advances money to the planters on the security of sugar warehoused and makes a final payment on receipt of the proceeds of sales in the United Kingdom on the basis of a certain premium for quality. In the early days it did not include the whole of the sugar producers of the island but, under recent Ordinances, it does so and the sale of sugar is thus completely centralized. It is noted by the Commission* that the small planter is not represented on the Syndicate.

By these means the sugar industry has taken steps to strengthen its financial superstructure; on the productive side, the raising of its raw material, cane, it has been less successful. The reduction of wages already referred to created a discontent among the labouring classes which culminated in the riots of 1937 involving a certain mortality. As a consequence, a Commission was appointed to investigate the causes and its Report, which has recently appeared, has been freely drawn on here. As usual under such circumstances, the cause is not simple for the discontent was not confined to the labouring classes and it actually came to a head among the small planters as the result of the cut of 15 per cent. which had been advertised in the price to be paid for 'Uba' cane. Uba cane, it may be mentioned, is not the Uba of Natal but is a term applied to a number of seedlings derived from the Natal Uba; Uba Fleuriot, Uba Marot, Canne Antelme, RF 1, RF 2 and so on, which have the main characteristics of Natal Uba and are disliked in the factory. Though considered to be eliminated from estate cultivation, 'seed' of these had been accidentally issued to the small planters in certain tracts and they were found by these to be well suited to the poorer lands cultivated by many of them. It is estimated that some 45,000 tons of Uba cane were raised in 1935. Two facts appear from the Report. It was less the matter than the manner of the cut which was the cause of the discontent. Though warnings were issued in 1935 that no further plantings of Uba cane should be made and that the factory reserved the right to reject at its weighbridges ratoons coming from crops of Uba in a fairly near future, a warning which was repeated in 1936, no organization existed interlinking the factory and the small planter by which the warning could be brought home. Under the circumstances, the posting of notices constituted inadequate warning to the small planters who are largely illiterate and, further, generally supply their cane not direct but through intermediaries. The announcement of the 15 per cent. cut, the implementing of the warning in specific form, came too late for the cane was already grown. The second point is that the outbreak would not have assumed the proportions it did but for the underlying general sense of frustration.

It is not possible here to analyse the deeper causes in detail. Briefly, the world movement among the labouring classes has not passed by Mauritius and here the demand for a higher standard of living has coincided with a depression in the industry which interposes great difficulty in the way of meeting the demand. In the case of the labourer it is a direct dissatisfaction with his wage; in the case of the small planter, it is dissatisfaction with the price he receives for his cane. In the latter case, the system of limitation of areas, under which the factories apportion out the area into spheres of influence, deprives the small planter of any bargaining power and this is emphasized under the system of contract through intermediaries or entrepreneurs which forces the small farmer to sell his cane through a particular entrepreneur. A further grievance of the small planter is the system of payment for cane on a sucrose basis. Theoretically an excellent system and, no doubt, the result of a gradual evolution, it is, as administered in Mauritius, liberal compared with the scale of payment elsewhere. But it has its disadvantages not the least of which is the inability of the small planter to understand or check the figures. A study of the Fahey agreement, which is given in an annexure to the Report, indicates the complexity of the calculation.

* *Loc cit.* p. 182.

In the present depressed state of the industry, it is questionable whether it is possible that higher payments should be made either to labourers or for cane supplied by small planters. The Commission recommend an increase of ten per cent. in labourers' wages and consider that the industry can afford it under present conditions but this is contingent on the maintenance of these conditions which lies beyond the control of the industry, particularly in the matter of world price and of Imperial preference

One remedy which is, however, at the disposal of the industry lies in the raising of the average yield of the small planter. A 20-ton crop costs little more to raise than one of ten tons and the small planter would raise his income by little less than the value of the additional crop. That objective, however, can only be achieved through the organization by the industry of a technical service acting as adviser and friend of the small planter. If experience elsewhere can be taken as a guide, such a system not only supplies cane at lower cost but builds up a spirit of co-operation which would render serious disturbance and discontent things of the past. Again, if experience is any guide, the lower cost of cane would make direct cultivation of cane unprofitable and even the larger estates including those with factories would profit by dividing up their lands into small holdings and leasing these, reducing thereby their direct labour bill and so solving the problem of the wage paid labourer. As long as indifferent crops are raised, quality, the percentage of sucrose in the cane, will vary within wide limits. With technical supervision including the rotational harvesting of the small planters' crops, this defect can be largely removed and the simpler system, readily comprehended by the small planter, of payment by weight becomes possible. The adoption of such a remedy, however, presents problems by no means easy of solution. Basically they concern land tenure. An estate can readily be divided up and the small holdings leased under terms which allow for technical supervision, but the aggregation of a number of small holdings and the superimposition of technical control is a more difficult matter.

The progress made in recent years in the cultivation of cane, especially through the introduction of new varieties is resulting in all countries in an ever increasing output of sugar per unit area and it is one of the ironies of the situation that, in the struggle for existence among the groups of producers in the various countries, the salvation of each group should be found in intensive cultivation leading to bigger crops and a further forcing of sugar onto an already overburdened market. Mauritius offers no exception to this rule and the movement along this road would be hastened by any raising of the standard of production of the small planter. The correction to this movement has been imposed from without under the International Agreement of 6th May, 1937, under which Mauritius with other countries is placed under a quota, fixed in the first instance for Mauritius at 267,000 tons, a figure exceeded in recent years in all but years of cyclone and/or drought. If Mauritius is not yet faced with the necessity of reducing the area under cane, it may soon be so faced and the problem of how to employ the excess land becomes a practical one. There are two possibilities. Reference has already been made to the economic weakness of the island arising not merely out of its too great a dependence on one crop but to the even greater weakness of its dependence on imports for its essential food. The two possibilities thus are an increase of home production of food and the development of alternative export crops.

The first of these appears to have received little attention if the few references are to form a guide. The question is linked with that already discussed, the extension of small holdings. With these systematically organized on an economic basis, of a size suited for family cultivation partly planted to cane and partly to food crops with access to grazing areas, the local supplies of home produced food could be largely augmented. Again this is a question of land tenure. Two secondary crops are fibre, Mauritius hemp (*Furcraea gigantea*), and tobacco. The major effort has been directed to the second of these crops. This dates back to 1928 and the earlier steps have been referred to in the earlier series of these studies. In 1930 was passed a comprehensive Tobacco Production and Marketing Ordinance (38 of 1930) establishing a Government Tobacco Board and registering all land growing tobacco and all dealers. In recent years a number of amendments have been passed, Ordinance 3 of 1934, tightening up the control, Ordinance 4 of 1935 defining the constitution of the Board as consisting of the Director of Agriculture, the Assistant Treasurer, the Commissioner of Excise, the Government Tobacco Officer, two representatives of growers and three of the commercial community, and the Tobacco (Consolidation) Ordinance (13 of 1934) controlling manufacturers for the purpose of excise. Preliminary efforts are also being made to explore the possibilities of fruit and reference is made to trial shipments of litchis.* The distance from any temperate market offers, however, difficulty.

A Co-operative Credit Societies (Amendment) Ordinance (26 of 1935) has been passed to amend the original Ordinance (4 of 1913). Little progress however appears to have been made in the direction of co-operation. A co-operative society is not in a position to enter into contracts with the factory and so replace the entrepreneurs who not only contract for cane but finance the small planter. Proposals have been put forward for the establishment of a Co-operative Credit Factory but the proposal has not been worked out and seems a retrograde step to take when the number of existing factories is already being reduced.

No legislative action has been taken in recent years in the matter of the control of pests except that, to finance the campaign against *Phytalus Smithi* instituted under the Plant Diseases Prevention Ordinance (8 of 1911), the Customs Tariff Sugar Export Duty (Amendment) Ordinance (38 of 1933) raised the export duty by one cent per Rupee to provide funds for the campaign.

* Dept. Agric. Report, 1936.

VIII. THE SUDAN.

The principles under which land tenure is determined in the Sudan have undergone little alteration and remain as described in the earlier series of studies. These principles, laid down in a series of Ordinances passed to serve the immediate purpose of meeting the confused situation which resulted from the devastations of the Mahdi and Khalifa, were consolidated in the Land Settlement and Registration Ordinance (23 of 1925). In view of the vast extent of the country, the paucity of the population and the comparative ignorance of both geography and peoples owing to the inaccessibility of much of it, it was wisely decided in this Ordinance merely to define the principles, to confine its operation to such areas as the means available rendered an adequate settlement possible and to leave its application to most of the territory to a later date, the various tracts being brought within its purview by special Gazette notifications. That position still stands. A movement, however, in the direction of devolution has been introduced by a series of amendments to the Natives Disposition of Lands Restriction Ordinance (3 of 1918), the latest of which is the Natives Disposition of Lands Restriction (Amendment) Ordinance (12 of 1932), giving power to the Governor to delegate his functions under the Ordinance to any Nazir, Omda or Sheikh within his province, or to any Court established under the Native Courts Ordinance (3 of 1932) when all parties are natives of the Sudan, but with right to appeal.

Present interest centres, therefore, in the development of that ambitious scheme of cotton cultivation in the Gezira. As has been recounted, this is a vast irrigation project with water supplied from the Blue Nile through the agency of a dam constructed at Senaar. The cost of the capital works, the dam and major canal system, was borne by Government and that of the minor canals together with the supervision of the cultural operations and the marketing of the crops by concessionaires, the Sudan Plantations Syndicate. The system of cultivation is indirect through tenants, though the major operations, such as ploughing, are undertaken centrally. The actual detailed cultivation, the planting, interculture, irrigation and picking of the crop, is performed by the tenants under the supervisory technical staff and the produce made over to, and processed (ginned) and marketed by the Syndicate. The terms of the tenancy are laid down in the Concession and payment for the produce is on a profit sharing basis. Further points of interest are the provision made to protect the rights of the original owners of the land and the precautions taken to prevent speculation in the enhanced value of the land resulting from the provision of water.

All these points have been sufficiently detailed in the earlier series of studies. It is on the subsequent developments that interest centres. One of these is the series of extensions to the area of the original concession. The primary object of these extensions was not the increase of production but a response to the necessity of meeting the ravages of those two major pests of cotton under Sudan conditions, black-arm and leaf-curl. The key to the control of these diseases lay in the elimination of the carry over on ratoon and volunteer (self-sown) cotton, and this was supplied by the introduction of a two-year fallow before cotton. This involved, when provision was made for food and fodder crops, the substitution of a four, for the, till then, three-year rotation with a consequent reduction of the area under cotton in any one year and a decrease on the turnover.

A further extension of the irrigated area in the Gezira took place as the result of negotiations in 1927 between Government and the Kassala Cotton Company, a Company closely associated with the Sudan Plantations Syndicate and formed to develop cotton growing in the Gash delta at Kassala. For reasons which it is unnecessary to enter into here, this earlier concession was cancelled and a concession of 46,000 acres in the Gezira granted in exchange. The financial terms are of no concern here, the essential point is that, in other respects, the conditions are similar to those of the concession held by the Sudan Plantations Syndicate, cultivation being through the agency of tenants who are paid for their produce on a profit sharing basis. Here, too, for similar reasons, additions have been made to the area originally included in the concession. Development by these two agencies has been on similar lines and may be considered together.

The climatic and soil conditions of the tract are not ideal for cotton and there is a consequent heavy toll from disease. Disease has, in fact, played an important rôle in the course of the development. One instance has already been mentioned. A further effect has been the introduction of a practice of eradication of all old cotton plants by the roots as a further protection against carry over of disease on ratoon plants. This gigantic task, the eradication of some 13,000 plants per acre over an area of some 200,000 acres has been successfully accomplished and the operation is completed in little over a month by the aid of a specially designed hand eradicator. The ease with which these changes were brought about must be attributed to the organization which supplied adequate supervision. Though relatively ineffective for the control of black-arm, the infection of which may be seed borne, these modifications of practice have been very effective in the case of leaf-curl. Since the introduction of eradication the amount of this disease has been negligible. This is in marked contrast to the effectiveness of an organization under direct official control implementing cultural practices laid down by the legislature or Government executive order. With it may be contrasted the actual experience of a field of peas following cotton in which the cotton plants had been left as support to the peas; and this, a field bordering an official agricultural experiment station in a country where the eradication of the cotton plants was the subject of legal enactment.

In a further effort to combat disease the assistance of the plant breeder has been called in and, in 1934, 11,000 feddans were planted to a selected strain of the main Gezira Sakel crop which had proved very resistant to leaf-curl.

The justification of this large experiment in devoluted agricultural production must be sought in two directions. Primarily it must prove itself to contain adequate safeguards for the independence of the native populations; secondly, it must be commercially successful. The severe economic depression, coming so early in the history of the experiment, has provided a test which might have proved fatal. But, on both heads, the experiment must be held to have justified itself. It is true that the tenants are drawn from communities which have little experience or desire for a high standard of living and, under such conditions, too rapid an accession of wealth may be actually harmful. The reaction to the depression is a reflection of this. Of the native cultivator it is stated that he "has accepted the violent fluctuations of fortune in a spirit of fatalism. Above all, he has been moved in many cases to work himself instead of always hiring labour. The prosperous early years bred bad habits and the ultimate salvation of the scheme lies to a great extent in the thrift and industry of the peasantry."*

Nevertheless, protection of the tenants against undue hardship is a necessity and steps were taken to this end in 1933 by the establishment of a Tenants' Equalization Fund under which half the outstanding debts of the tenants in the adverse seasons 1931-32 was borne by Government and in order to protect the tenants generally against bad years; † to this fund the two organizations make regular contributions. This guarding of the interests of the tenants is primarily the function of Government but it is hardly less important that the concessionaires should also realize the desirability of having a satisfied and solvent tenantry. That this realization exists is shown by the efforts made to reduce the costs of services to this end.‡

On the financial side the experiment must be considered a success. It is not here possible to review the capital adjustments made by the two organizations during the development and expansion period but, in spite of the depression affecting the cotton market as others, both organizations have progressed and have, in recent years paid an increasing dividend, the last declared of which (1937) was, in both cases, 10 per cent. plus a bonus of 2½ per cent. while the shares have stood consistently at a premium; the £ shares of the Sudan Plantations Syndicate fluctuating between 28s. and 57/6 since the beginning of 1937 and the 1s. shares of the Kassala Cotton Company between 1/6 and 1/10.

* Cmd. 4159 (1932).
† Cmd. 4387 (1933).
‡ Speech of Chairman, Sudan Plantations Snydicate, 1932 and 1933.

That the desire for a higher standard of living among the relatively backward peasantry may become a factor of which account will have to be taken, is a possibility which cannot be overlooked. The process must, however, be slow; the danger of too rapid progress in this direction has already been mentioned. Guidance in this matter must lie with Government and it holds the means in the revisionary powers contained in the terms of the concession.

Reference has been made to the cancellation of the concession of the Kassala Cotton Company in that other extensive cotton growing area, the Gash delta. This area has reverted to Government and is administered under conditions which have been sufficiently noted in the earlier series of studies.

There remains one further development; it is that extensive development which has taken place in recent years in the Nuba Mountains Province of the southern Sudan. This is a tract of extensive plains interrupted by more or less isolated 'gebels' or mountains which formed fastnesses for the indigenous population during the devastations of the Mahdi. At the time of the writer's visit to the Province in 1924, much of the timidity still remained and contact with the peoples was being established with difficulty. Since that date confidence has been secured and considerable progress made with the cultivation of rains grown cotton of the Upland type. An account of this development in its agricultural aspect has been given by March.*

Since the population is largely aggregated on the gebels standing in extensive plains and it is on these plains that cotton is grown, land is abundant. It is merely necessary to descend to the foot of the 'gebel' to secure all the land required. These are conditions under which an indigenous system of tenure remains nebulous and the need for the early definition of such a system in any detail lacks urgency. Nevertheless a basis requires to be laid down and this basis is that, technically, Government owns the land but recognises the right of the local population to cultivate the land in their neighbourhood. This right belongs to the tribe, and individuals or families obtain the right to cultivate those particular plots which they have cleared with the permission of the head of the tribe. This right is not hereditary though active cultivation confers on the actual cultivator a preferential claim. There is, thus, in process of evolution a system or code of customary rights and in that custom is included a right to such land for three years during which no one else may cultivate the plot even though the holder fails to cultivate it himself.

There is one potential danger in view of the probable increase of the population resulting from the pacification of the country. It arises from the profitable nature of cotton growing and the inducement thereby offered to 'strangers' to take up land. It is a danger which is being watched and, at present, no 'stranger' is allowed to cultivate land without prior permission from the head of the tribe, to whom a small rent is paid.

*G. F. March, *Emp. Jr. Exp. Agric.*, 4 (1936) No. 13.

A NOTE ON A UNIFORMITY TRIAL WITH OIL PALMS.

By C. C. Webster, B.Sc., A.I.C.T.A.,
Department of Agriculture, Nigeria.

Introduction.

The work here described was undertaken with a view to obtaining information likely to be of guidance in designing field experiments with oil palms in Southern Nigeria. Although investigations of a similar nature have been made with several other tropical permanent crops, for example cocoa (1) tea (2) and coffee (3), so far as the writer is aware nothing of this kind has been published with reference to oil palms, and consequently no information is available regarding such matters as the variability of the crop, the effectiveness of various methods of dealing with yield data, the size of plot required, and the differences between treatments which could be shown to be significant. It was hoped that the uniformity trial here reported would yield information on these points which would be of value in planning field trials.

2. Material.

The yield figures for analysis were obtained from a block of 10 acres of palms on the Departmental Farm near Benin. Some notes on these palms have already been published by Kincaid (4). The planting of this area was commenced in 1923 but very little progress was made in the first two years, and for all practical purposes the planting date may be regarded as 1925. The palms are spaced at 25 feet square, and for this trial a square block of 576 palms (24 x 24) was used. To provide the planting material for this area seed was taken from wild palms in the neighbouring bush without any attempt at selection. Records of the weight of bunches have been kept each year since the palms commenced bearing, for each palm. The block contains over 98 per cent. of palms of the type termed by Smith and Toovey (5) " Ordinary type : Thick shell palm ". The average yield of bunches per palm is given for each of the four years 1934-37 in Table 2, the mean annual yield being 89.8 lb.

Mr. Doyne, Senior Chemist, Department of Agriculture, Nigeria, describes the soil of the block as a highly acid red sand typical of the soils of the Acid Sand type, and has provided the following analysis : Stones : nil, Coarse Sand, 64.5 per cent. Fine Sand 6.3 per cent. Silt 1.3 per cent. Clay 27.9 per cent. pH. 4.2, total exchangeable bases 0.57 milli-equivalents per cent. carbon : 1.030 per cent. : Nitrogen 0.074 per cent. C/N 13.9 (Coarse sand would probably be slightly lower and Fine sand proportionately higher with more recent methods of analysis). The average annual rainfall at the farm is 80 inches.

3. Methods.

The procedure adopted was to superimpose upon the yield plan eight different randomised block layouts corresponding to eight different plot sizes, viz. : (See plot arrangement below).

It will thus be seen that the whole of the 576 palms were used in each layout. The shape of the plots varied to some extent, some being square, and others shortly rectangular but it is not considered that this variation was sufficient appreciably to affect the results. The form of analysis of variance adopted throughout is shown in Table 1 below.

No hypothetical treatments were allotted to the plots and after the removal of the variance due to blocks the whole of the residual variance was used for the calculation of the standard error. The yields analysed were those for lb. of bunches per palm, and no other data, such as fruit weights, &c., have been investigated.

4	palms	per	plot	...	...	144	plots	...	...	12	randomised	blocks	each of 12 plots.
12	do.	do.		...	...	48	do.	...	...	8	do.	do.	do. 6 do.
16	do.	do.		...	...	36	do.	...	...	6	do.	do.	do. 6 do.
24	do.	do.		...	...	24	do.	...	...	6	do.	do.	do. 4 do.
32	do.	do.		...	...	18	do.	...	...	6	do.	do.	do. 3 do
36	do.	do.		...	...	16	do.	...	...	4	do.	do.	do. 4 do.
48	do.	do.		...	...	12	do.	...	...	4	do.	do.	do. 3 do.
64	do.	do.		...	...	9	do.	...	...	3	do.	do.	do. 3 do.

Table 1.—Analysis of Variance, 16 palms per plot, 1937.

Variation due to	Degrees of freedom.	Sum of squares.	Mean square.	S. E. mean.	$\frac{1}{2}\log_e$ mean square.	z calculated.	z (Fisher).
Blocks ...	5	3256	651.0	—	.93667	—	—
Residue ...	30	8088	269.6	16.42	.49590	.44077	.4648 (P=0.05)
Total ...	35	11344	—	—	—	—	—

FIG. 1

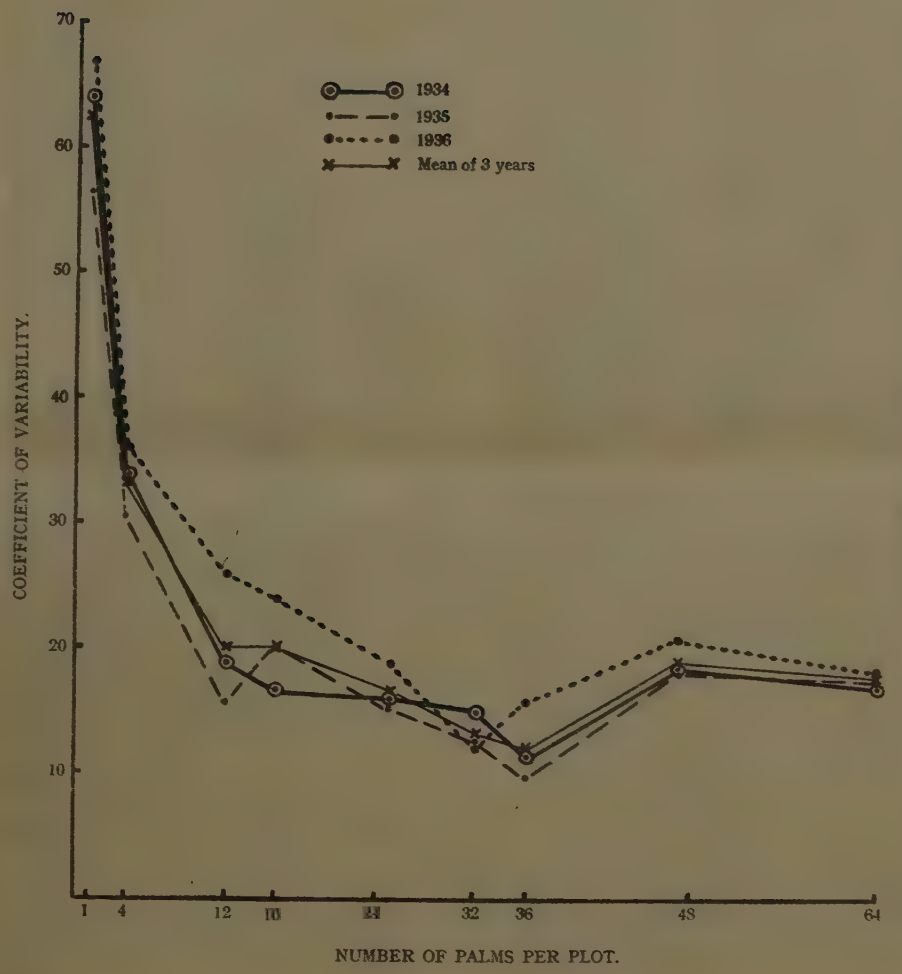
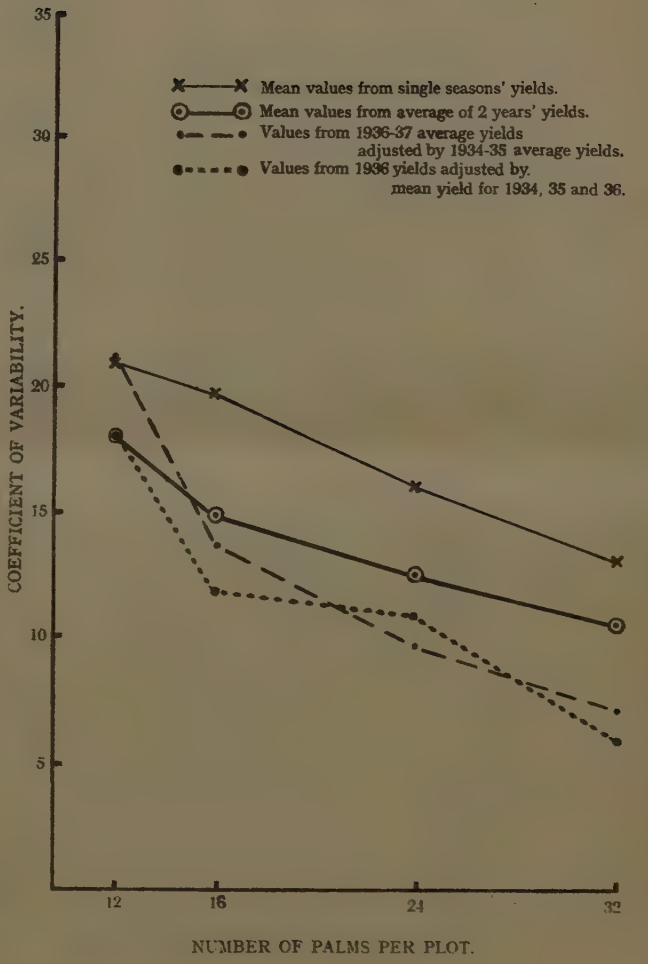

1934
1935
1936
Mean of 3 years
COEFFICIENT OF VARIABILITY.
70
60
50
40
30
20
10
1
4
12
16
24
32
36
48
64
NUMBER OF PALMS PER PLOT.

FIG. 2


Mean values from single seasons' yields.
Mean values from average of 2 years' yields.
Values from 1936-37 average yields adjusted by 1934-35 average yields.
Values from 1936 yields adjusted by mean yield for 1934, 35 and 36.
COEFFICIENT OF VARIABILITY.
35
30
25
20
15
10
5
12
16
24
32
NUMBER OF PALMS PER PLOT.

It may be mentioned that the figures for a single year were also analysed on the basis of four Latin Squares corresponding to plot sizes of 4, 16, 36 and 64 palms. The coefficients of variability obtained followed closely those from the randomised block layout but were a little higher throughout, as block variance was invariably lower. This may be attributed to the fact that soil differences on the plot tend to occur in patches rather than in the form of a fertility gradient, and that another source of major variation is the existence of a patch of palms which are poorer than average on account of their early treatment. In consequence the randomised block design was the more effective in eliminating major variations. It was for this reason, and also because it allowed a wider range of plot size to be tested that it was adopted in preference to the Latin Square.

4. Results.

(a) The Use of Yields from a Single Season.

The first step taken was to analyse by the method described above the annual yields per palm for the years 1934, 1935, and 1936, and the results are shown in Table 2, where they are expressed as the coefficients of variability (Standard Error expressed as a percentage of the general mean) for each size of plot. These figures are also illustrated in fig. 1. The coefficient of variability decreases sharply as the plot size increases from 1 to 16 palms, and then more slowly up to 36 palms per plot. There is a slight rise again with the 48 and 64 palm plots due no doubt to the fact that soil variation, &c., cannot be effectively eliminated in the block variance with these large plots. Block variance was invariably greater than residual variance (and usually significantly so) in all cases up to 36 palms per plot, indicating that the layout was effective in removing much major variation. The unusually low values for the 36 palm plots are of no significance as they are due to a lucky placing of the blocks. Taking this last point into consideration it appears that there would be no appreciable advantage in increasing plot size above 32 palms, and that it would be unwise to use plots of less than 12 palms. The 1936 figures gave noticeably higher values than those from other years. This high variability may have been due to the effect of an unusually dry season.

Practical considerations naturally set a limit to the size of plot which can be used in field experiments, but under Nigerian conditions plots of half an acre (28 palms at the present spacing of 29 feet triangular planting) would not be too large. The differences which could be shown as significant with P=0.05 (a 20 to 1 chance) are shown in Table 5, from which it may be concluded that with plots of half an acre replicated 6 times a difference of 20 per cent. could be demonstrated. It is considered that an experiment must be able to prove differences not larger than 20 per cent. if useful results are to be obtained.

(b) The Use of Mean Yields for Two and Three Seasons.

The next step was to see if the coefficient of variability could be reduced by using the average yields for more than one season. As it was evident from the results already detailed that plots of less than 12 or more than 32 palms would not be satisfactory, further work was confined to only four plot sizes, viz.: 12, 16, 24 and 32 palms. The average yields for 1934 and 1935, 1936 and 1937, and 1934, 1935 and 1936 were obtained, and analysed for these four sizes of plot. The resulting coefficients of variability are shown in Table 3. The figures for 1936 and 1937 are distinctly higher than those for 1934 and 1935 presumably on account of the high variability of the 1936 Yields already mentioned. It is fairly clear, however, that the use of the two year averages has reduced the variability, but in this case the use of a three year average has not done so to any appreciably greater extent. This again may be partly due to the inclusion of the 1936 figures, but on the other hand it was not expected that the three year averages would be much, if any, more effective than the two year means, since a study of the yield records showed that approximately 40 per cent. of the palms have a distinct tendency to biennial bearing. Reference to Table 5 indicates that if two year averages are used then half acre plots replicated six times may be expected to demonstrate as significant a difference of about 15 per cent. between treatment means, while a 20 per cent. difference could be proved with plots of 16 palms (slightly more than a quarter of an acre) similarly replicated.

Table 2.—Coefficients of Variability (Standard Error of a single plot as percentage of mean).

Year.	Mean yields lb. bunches.	Coefficients of Variability. Number of palms per plot.								
		1	4	12	16	24	32	36	48	64
1934 ...	80.3	63.94	33.66	18.66	16.37	15.91	14.72	11.07	18.10	16.37
1935 ...	107.4	56.52	30.35	15.41	20.15	15.04	12.33	9.49	17.86	16.97
1936 ...	85.7	66.86	35.85	25.81	23.76	18.49	11.95	15.23	20.37	18.95
1937 ...	85.9	—	—	24.40	19.06	14.92	13.13	—	—	—

Table 3.—Coefficients of Variability (Standard Error of a single plot as percentage of general mean).

Year.	Number of palms per plot.			
	12	16	24	32
Mean yield (1934-35) ...	13.96	11.12	10.62	11.21
Do. (1936-37) ...	22.40	18.77	14.32	9.96
Do. 1934, 35 & 36	14.23	12.10	10.98	10.11

(*c*) *The Use of Previous Records.*

A third possibility is to make use of previous records to correct the Yield figures for a single experimental year by means of the regression function between the two variables. Using the method described by Wishart and Sanders (6) this has been done in four ways :—

(1) One year's records corrected by covariance with the previous year's records.

(2) One year's records corrected by covariance with the mean of the previous 2 years yields.

(3) One year's records corrected by covariance with the mean of the previous 3 years yields.

(4) The mean of two years' yields corrected by covariance with the mean of the previous two Seasons' yields.

In the case of (1) and (2) it was found that regression was not significant, this result not being altogether unexpected in view of the occurrence of a fair proportion of biennially bearing palms. The other results are summarised in Tables 4 and 5 where they are also compared with the coefficients of variability obtained from single season's yields and from two year averages. The use of previous season's records as indicated under (3) and (4) above has resulted in a reduction in the variability compared with that obtained by using only a single season's yields and has been rather more effective in this respect than the simpler method of averaging two years' yields. Considering again the half acre plots replicated six times, the significant difference has now been further reduced to 10 to 12 per cent., and with 16 palms per plot to 15 to 17½ per cent.

***Table 4.—Coefficients of Variability (Standard Error of a single plot as a percentage of the general mean).**

	Number of palms per plot.			
	12	16	24	32
Mean values from single year's yields ...	21.07	19.83	16.09	13.03
Mean values from 2-year averages ...	18.18	14.94	12.47	10.58
1936-37 average corrected by covariance with 1934-35 average ...	21.14	13.69	9.66	7.18
1937 yields corrected by covariance with mean yield for 1934, 35 and 36 ...	18.18	11.82	10.81	5.96

* See also Fig. 2.

5. Summary and Conclusions.

The conclusions which can be drawn from these figures may now be summarised. It is evident that in field trials on this area there would be no appreciable advantage in increasing the size of plot above 32 palms. As the error values rise with increasing rapidity the smaller the plot becomes it is clear that plots of less than 12 palms would be unsatisfactory, and the indication is that the useful range of plot size is from 16 to 32 palms. Practical considerations naturally limit plot size to some extent, but for most purposes in Nigeria plots of half an acre would be quite suitable, and in this trial such plots, replicated six times, might have been expected to demonstrate as significant a difference of :—

(*a*) Twenty per cent. if only a single season's yield are used.

(*b*) Fifteen per cent. if the average of two seasons' yields are used.

(*c*) Ten to twelve per cent. if four seasons' yields are available and the yields for the experimental year are corrected by the method of Sanders and Wishart (6) as already described.

Table 5.—Significant differences between treatment means expressed as percentages of the general mean.

Number of palms per plot. ...	16			24			32		
Number of replications	4	5	6	4	5	6	4	5	6
Mean values from single year's yields ...	34.31	2 '.97	25.48	27.83	23.46	20.69	22.54	19.00	16.76
Mean values from 2-year averages ...	25.86	22.30	19.22	21.58	18.18	16.04	18.41	15.43	13.30
1936-37 average corrected by covariance with 1934-1935 average	23.69	19.97	17.61	16.71	14.09	12.43	12.42	10.47	9.23
1937 yields corrected by covariance with mean yield for 1934, 1935 and 1936 ...	20.46	17.23	15.21	18.71	15.76	13.90	10.31	8.69	7.66

If, however, it was considered sufficient to prove differences only as low as 20 per cent., the size of plot might be reduced to 16 palms (slightly more than a quarter of an acre) provided that at least two seasons' yields were available.

The occurrence of a fair proportion of biennially bearing palms is noteworthy and must be taken into consideration in using more than one season's yields.

How far these results will be found generally applicable it is impossible to say as it has not been possible to check them by uniformity trials situated elsewhere, but they will at least serve as a rough guide in planning field trials with oil palms in Nigeria.

Acknowledgments.

The helpful advice of Mr. F. W. Toovey and the assistance of Mr. J. L. B. Kincaid in supplying yield figures are gratefully acknowledged.

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MYCORRHIZA IN RELATION TO SOIL FERTILITY.*

THERE is accumulating evidence to show that the problem of fertility is not the simple one it had been thought, capable of mathematical solution; the addition of so much plant food yielding so much increase of crop. Nature does not work so simply; there are subtle biological influences at work, more prominent in tea and certain other perennial crops, perhaps, owing to the presence in these of a mycorrhiza, a symbiotic association of specific fungi with the root of the crop plant, but important in all circumstances in view of the rôle played by micro-organisms in the soil.

The mechanism by which the mycorrhiza acts is intermediary between the humus and the crop plant is undetermined; the recognition of its importance is too recent. Much valuable information as to the reality of some mechanism is supplied in a paper by A. Howard.† The association of bacteria with the roots of leguminous plants, leading to the formation of nodules, has been known for a very long time. It is the capacity of these bacteria to fix free nitrogen for the enrichment of the plant that renders leguminous plants so valuable as manure. But the story does not end there; nodule formation is not adequate to carry the leguminous plant to maturity without the addition of humus to the soil. Plants such as *Crotalaria anagyroides*, grown to supply green manure, commonly fail to set seed under the monsoon conditions of India unless supplied with humus, and it is of interest that an examination of the roots of *C. anagyroides* which had been manured with compost showed both nodules and mycorrhiza but never together on the same rootlets. Further, leguminous vegetables like French beans, when grown on poor soil only or under the stimulus of artificials, are tasteless and of poor quality, and the question is asked whether quality and disease resistance both depend on the same factor, the perfect synthesis of proteids and carbohydrates. It would seem so and that this perfect synthesis results from the presence of a vigorous mycorrhizal development, for the response to compost on worn-out tea lands has been immediate, far greater than can be explained by any improvement in the physical condition of the soil and accompanied by very definite increased resistance to red spider (*Tortrix*) and mosquito blight (*Helopeltis*), those two pests of tea.

The nature of the mechanism is, as has been said, undetermined. There may be in the compost growth-promoting substances for which the mycorrhiza forms a protected passage to the plant thus protecting them from absorption by the soil population, or the fungi may be capable of providing essential materials for the manufacture of such substances in the plant itself. Further work alone will determine the question. Meanwhile some indication as to the nature of these substances is given in a paper by H. Nicols.* There is a group of substances of which indole acetic acid is an example, closely associated with the excretory products of animals, which are known to promote growth, or as here expressed, regulate growth. Already their use has been commercialized in the product Hortomone used for stimulating the rooting of cuttings. Their association with the excreta of animals used in the preparation of humus, is suggestive.

*The following abstract forms part of an article on "Fertility and Humus" by Dr. H. M. Leake in the *International Sugar Journal*, Vol. XL, No. 476, pp. 294-96, 1938.

†*Empire Cotton Growing Review*, 15, p. 215, 1938.

* *The Manufacturing Chemist*, 8, p. 75, 1937.

The gradual progress of scientific discovery in its bearing on practical problems appears to be subject to interruptions when a light appears which throws open a whole new field in man's command over nature. Of such a kind were those of Liebig, Pasteur and Mendel, to mention only three in the biological field. It is possible that, in the agricultural field, the recognition of the importance of the rôle of mycorrhiza may play as important a part. There is reason to believe that mycorrhiza will be found associated with the roots of many agricultural plants and it is understood that its presence in association with the roots of the sugar-cane has been observed. Nature appears to have provided this special mechanism for the utilization of humus, and mycorrhiza has been observed in a sufficiently diverse series of plants to suggest that the phenomenon of its presence is more general than has hitherto been supposed. Should that prove to be the case, the bearing of the fact on future manurial policy and on disease resistance becomes obvious. Meanwhile, it is not necessary to await the detailed determination of the mechanism; sufficient is already known to permit advance on the practical application.

REVIEWS.

SOILS OF THE LUSITANO-IBERIAN PENINSULA (SPAIN AND PORTUGAL).

By E. H. del Villar, Spanish and English Edition (English text by G. W. Robinson), Madrid, 1937, *Thomas Murby & Co.*, London. pp. 416, with separate coloured map, price 40s.

Scientific interest in the soils of Spain and Portugal lies mainly in the fact that they represent transition types between those of North and Central Europe, formed under a wet temperate climate, and those of Mediterranean Europe and North Africa, formed under arid conditions. The work comprises an individualistic attempt to classify the soils according to a strictly objective system, and its study, according to Professor Robinson, must inevitably modify and correct not only the earlier systems of other authors, but also current ideas on soil genesis and classification. Agricultural and human interest in Professor del Villar's work lies in its assessment of the effect of centuries of land exploitation and of man's interference, whereby the natural resources of the soil have been aimlessly squandered.

Present-day pedologists, inspired by the researches of the pioneer soil investigators who have attempted to classify the soils of the better-known countries, are rapidly accumulating vast masses of information, both by means of field studies and laboratory analyses, which sooner or later must be collated with a view to a final world classification of soils. As each new and distinctive area is studied and the results published, the problem of incorporating the findings into existing schemes becomes more and more difficult. Yet the attempt may serve to test the universal applicability of the suggested systems and for that reason, freedom of personal expression should be allowed, in the hopes that, through a process of elimination, a really satisfactory world scheme of soil classification will eventually emerge.

To this end, Professor del Villar's accumulated experience should be carefully considered by all students of pedology, and the importance of his contribution duly recognised. English-speaking students owe a special debt of gratitude to Professor Robinson for undertaking the task of translation.

The most characteristic Spanish soil (termed "Calvero" by Professor del Villar), occupying more than half the total area and widespread in the arid areas, seems to have no strict counterpart in any other part of the world. It shows a red-brown profile, devoid of lime accumulations, and has a low content of humus. The profile has been modified by human interference and truncated by erosion. Its nearest affinity seems to be Red Loam formed under tropical savannah and monsoon forest. Other widespread Spanish soils have been derived from limestone, for example, "Terra Rosa", occurring mainly in the eastern half of Spain; others are described as peaty, and occupy a large area in north-west Portugal. These and their variants, as well as other soil-types of more local occurrence, are depicted in colours on the map to a scale of one to one-and-a-half million, together with a descriptive legend. The text contains 28 beautiful reproductions of photographs of soil-profiles and scenery, and 87 tables of chemical analytical data, which serve to identify the different soil-types.

F. H.

* * *

SOILS AND MEN: YEARBOOK OF AGRICULTURE, 1938.

U. S. Department of Agriculture. *U.S. Govt. Printing Office;* pp. 1232. Price $1.75.

This book is one of a series of Yearbooks dealing with aspects of modern North American agriculture; those for 1936 and 1937 covered genetics and breeding of the full range of crops and farm animals of the United States; that for 1939 is to consider the newer knowledge of nutrition of farm animals and human beings. Probably no other book has dealt with soils from so many angles as this; more than 100 authors, each a recognised authority in his own subject, have contributed to it. The book is divided into five parts; Part I, The Nation and the Soil, deals with soil misuse from the economic and social point of view; Part II, The Farmer and the Soil, deals with general soil management; Part III, Soil and Plant Relationships, considers plant requirements and

the soil's ability to meet them; Part IV, Fundamentals of Soil Science, discusses the physics, chemistry and biology of soil, and Part V, Soils of the United States, describes the soils of the nation and its territories (Puerto Rico, the American Virgin Islands, the Hawaiian Islands, Alaska and the Panama Canal Zone), and is based on the work of the Soil Survey Division. A very striking soil map has been specially prepared for this book. There is a glossary of special terms, a reference list of literature and a full index.

The first four parts are summarised in the opening chapter (44 pages), and a portrait of the late Dr. C. F. Marbut, Chief of the Soil Survey Division, to whose memory the book is dedicated, forms a frontispiece. The Secretary of Agriculture (Henry A. Wallace), in a Foreword, indicates the real cause of the compilation—" The social lesson of soil waste is that no man has the right to destroy soil. . . . The soil requires a duty of man which we have been slow to recognise. In this book, the effort is made to discover man's debt and duty to the soil ". As would be expected, soil erosion, which is the main reason for the devastating floods that have created such enormous losses in recent years, receives special attention in six chapters (97 pages).

The book's subject-matter is most readable and interesting; the only drawback is the massiveness of the volume (it weighs over four pounds); the printing and arrangement are excellent. Every student of agriculture should have a copy on his desk for frequent consultation; its fifty-nine chapters, if studied one per week, would furnish him with a summary by an expert of practically every important branch of modern soil science in its widest agricultural application.

F.H.

* * *

A WORLD TOUR FOR THE STUDY OF SOIL EROSION CONTROL METHODS.

By A. Grasovsky. Imperial Forestry Institute, Oxford. Institute Paper 14, 1938. Mimeographed, pp. 77. Price 5s.

This is a report of an official of the Palestine Government who made a tour during 1936-37 of Nigeria, the Sahara, Algeria, Morocco, parts of the United States of America, Japan, Java, Malaya, Ceylon and India, arranged by the Oxford Forestry Institute, for the purpose of studying the control of soil erosion and the rebuilding of forest soils on land degraded by overcutting and overgrazing. Dr. Grasovsky studied forestry at Berkeley and at Yale, and travel grants were afforded him by the Carnegie Corporation.

The report is divided into sections dealing with each country or area in turn. The subject-matter is most interesting, and avoids repetition of the descriptions of erosion control measures that have been fully dealt with in recent literature and text-books. The characteristic local methods and reasons for them are considered instead, and obvious facts are deliberately omitted. Thus the report offers many original ideas that could only be learned of with difficulty elsewhere, and the author's keen perception and ability to express himself tersely yet clearly render the reading most stimulating. Several adequate diagrams and photographs aid in conveying the correct impressions. It is hoped that Dr. Grasovsky may be persuaded to extend his report into a printed book, for such would be a most useful addition to the literature of soil erosion.

F. H.

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PLANT GROWTH-SUBSTANCES. THEIR CHEMISTRY AND APPLICATIONS WITH SPECIAL REFERENCE TO SYNTHETICS.

By H. Nicol, *Leonard Hill Ltd.*, London, 1938, pp. 108.

This publication will appeal rather more to the chemist than to the physiologist, containing as it does much which reads like a text-book on organic chemistry. It will form, none the less, a useful addition to the literature on the subject of growth regulating substances in plants.

The first two chapters are for the layman, outlining the simple techniques for inducing root formation in cuttings; the third chapter deals with the organic syntheses of the growth regulating substances, followed by one on the results of scientific work on the effects of the synthetic growth-compounds. Subsequent chapters deal with the natural occurrence of growth regulating hormones, with their chemistry in relation to the processes of growth and with the classification, nomenclature and identification of growth substances.

Not the least useful feature of this small book is the appending of numerous references at the end of each chapter and the outlining, in tables, of tests and properties of the substances which form the subject of the book.

F. W. C.

MONKEYS AS BOTANICAL COLLECTORS.

The *Kew Bulletin* No. 7, 1938, quotes from the annual report of the Director of Gardens, Straits Settlements, an account given by the acting director, Mr. E. J. H. Corner, of the use made of berok monkeys (*Macacus nemestrina*) to collect specimens from tall trees. Two young beroks are at present employed; they understand twelve words of Kelantanese and can thus be instructed to pick specific twigs, and drop them to the ground. Mr. Corner states, " A berok upon the shoulder can be likened, in effect, to a falcon on the wrist; and its employment is recommended both to amateurs for its charm and cheapness and to keepers of Reserves where it is desirable to collect specimens repeatedly from the same trees without damage to them".—(*Nature*, Vol. 142, No. 3604, pp. 949-50, 1938.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Soil Erosion in Tanganyika.

An interesting memorandum on soil erosion, by E. Harrison, Director of Agriculture, Tanganyika, has been issued by the Government of the Territory. A representative committee appointed to advise on the problem formed the opinion that the primary method of attack should be educative rather than ameliorative, and with this end in view the already existing authorities, such as forestry, veterinary and agricultural officers, were instructed to demonstrate the serious nature of the loss caused by soil erosion, and to arouse interest in the methods by which it could be checked. In some districts the systems of land management evolved by the native cultivators were practically ideal counters to water erosion, but in others considerable time and patience will be required before the value of, and necessity for, adopting entirely new practices are realised. The relations between over-stocking and soil erosion are particularly intricate. The native husbandman is only capable of maintaining large numbers of cattle on land more or less denuded of persistent vegetation, as otherwise he incurs the ravages of ticks, flies and worms, and these are just the conditions which accelerate soil erosion. In view of this, the director of the veterinary services has outlined a scheme by means of which overstocking may be relieved. The chief items are: expansion of a rotational grazing system, increased water supplies and the control of the type and number of stock carried, and control of grass burning. Application of scientific knowledge coupled with some form of legislation is regarded as the best way of furthering the interests of the native. Anti-erosion rules have already been drawn up in a number of districts, with considerable success. (*Nature*, Vol. 142, No. 3587, pp. 216-17, 1938.)

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Studies in the Preservation of Fruit Juices.—I.—Some Observations on the Preparation and Preservation of Citrus Fruit Squashes.

On the basis of analysis of samples of eighteen different brands of citrus squashes available in the market, various batches of squashes of orange (Malta), lemon (imported varieties and *galgals*) with different sugar concentrations (35°, 45° and 65° Balling strength) preserved by different methods of preservation, were prepared and stored at room temperature for a period of 1¼ years. Their behaviour during storage has shown that:—

1. Citrus fruit squashes with high sugar content (65°B) retain their fresh-fruit character to a marked degree.

2. Addition of thoroughly ground and strained peel emulsion considerably improves the flavour and aroma of the bottled product. This is more marked in squashes with high sugar content, whereas a slightly bitter taste is imparted to the products having low sugar content.

3. Preservation with sulphur dioxide yields a product superior in taste, flavour and odour to that preserved with sodium benzoate or Pasteurization. Sodium benzoate, even in the purest form, imparts a peculiar chemical odour, resembling iodoform, and a burning taste to the product, whereas Pasteurized squash develops an unpleasant cooked flavour. Sulphur dioxide imparts a slight sulphurous odour to the freshly prepared product which is not noticeable in the diluted beverage, but this adverse effect disappears in about nine months' storage at room temperature.

4. For effective preservation, the maximum permitted concentration of sulphur dioxide (350 parts per million) can be diminished (say 100 to 200 p.p.m.) in squashes with high sugar content. It is convenient to add sulphur dioxide in the form of potassium meta-bisulphite (a salt containing about fifty per cent. sulphur dioxide).

5. Pasteurized squash, once opened during summer months, becomes spoiled within three or four days, whereas the chemically preserved squash, occasionally opened and recorked in the laboratory, shows no sign of infection, even when kept in this condition for over two months.

6. Sets of squash other than those preserved with sulphur dioxide, undergo marked colour changes (pale yellow to deep brown) in about 1¼ year's storage, whereas the bleaching action of sulphur dioxide seems to arrest these adverse colour changes effectively.

7. Rate of settling of sediment in the Pasteurized squash is much slower than in the chemically preserved squash; colloidal suspension (cloudiness) persists in the former even after one year's storage.—(Lal Singh & Girdhari Lal.—*Ind. Journ. Agr. Sci.*, Vol. VIII, Part 1, 1938, p. 77.)

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Manufacture of an Insoluble Road Composition from Molasses. *By H. D. Sen.*

Promising results are claimed to have been obtained in the manufacture of a road composition, using alkali "catalyst" for the resinification of molasses with asphalt.* In later work a molasses-asphalt-coaltar composition has been prepared with an acid catalyst, which is an improvement on that previously proposed. Substitution of half the asphalt with coaltar has given a better resinification with the production of a composition which is more easily transported and applied. Composition 5, for example, consists of: Concentrated molasses, 74.39, sulphuric acid (1.84) to be added to the molasses, 0.74; asphalt, 12.31; coaltar, 12.31; and sulphuric acid to be added to the mixture of asphalt and coaltar, 0.25 per cent. Its cost of manufacture comes to Rs. 51 per ton, taking molasses at 0-8-0 annas per maund, and Rs. 45 when the price is 0-4-0, as compared with the market price of asphalt at Rs. 160 per ton. A "seal coat" is necessary for the prevention of peeling off.—(*Int. Sugar Jr.*, Vol. XL, No. 478, p. 405, 1938.)

* *I. S. J.*, 1937, p. 445; 1938, p. 276.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Research on Manufacture of Rum.—*By R. Arroyo.* A research project on the symbiosis of the "Pombe" yeast with the bacterium *Clostridium saccharo butyricum* (Arroyo) has been carried to completion. These two organisms together produce a rum which always runs higher in ester content (two to five times) than rums produced by yeast without symbiosis. Such rums age at a faster rate when stored in oaken kegs. The aldehyde content is lower and the acid content higher than in non-symbiotic rums; the fusel oil content is lower. The fermentation period is short; that is, the yeast is activated by the bacillus. The procedure has now been reduced to a semi-commercial scale. To quote the author "We intended to produce a rum with the characteristics, peculiar and inherent, of pure Jamaica rum. We have produced a rum indistinguishable from Jamaica rum in taste, bouquet, and chemical analysis. Furthermore, we can manufacture this rum in a fraction of the time required for the confection of rums of similar quality under Jamaican methods and conditions. All of our three months' old rums offer the chemical analysis of a two-year old Jamaican while the six months' old are comparable with five-year old Jamaican."—(*Facts about Sugar*, Vol. 33, No. 8, p. 37, 1938.)

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Utilization of Molasses. *By A. R. Lamb.*

Considerable progress has been made in working out the conditions for a good yield of lactic acid (edible quality), the best yield to date being from an organism isolated locally, viz.: 42 per cent. of the sugar present. This yield can be considerably increased when ideal fermentation conditions are worked out for this particular organism. *Yeast*—Work on the production of yeast in quantity from molasses was recently begun, the aeration process, which furnishes an abundance of oxygen for the propagation of the yeast cells, being used. Little alcohol is formed, and provided an abundant supply of oxygen is furnished, together with an appropriate concentration of inorganic nutrients and ammonium salts, yeast proteins (which make up over 50 per cent. of the dry matter), are synthesized from the sugar molecule and ammonia. The yield at this time is at the rate of about 2.7 lb. of compressed yeast per gallon of molasses. This yield may be increased at least 50 per cent. by further study with different yeast strains. The product is light chocolate-brown in colour, of good flavour, and is edible, but so far not pure enough for use as bakers' yeast. *Animal Feeding*—A co-operative experiment with the Hamakua Mill Company and Kukaiau Ranch has been completed. Hereford steers were fed for three months in small lots on a ration of molasses, bagasse, pineapple bran, soybean oil meal, bone meal and cane tops. The animals were in good condition of flesh at the beginning, and individual gains were as high as 100 to 120 lb. in one month. When cooked, the meat was at least as good as that currently imported from the mainland, being declared excellent by representatives of the Army and Navy meat inspection staffs. *Syrup*—A golden-yellow syrup has been prepared, which has a taste similar to either the best grade of "New Orleans molasses" or a syrup prepared from fresh cane juice. *Levulinic Acid*—Then U. K. Das reports from the Biochemical Laboratory, that a process has been developed by which the sugars of molasses can be converted into levulinic acid, the inorganic salts being recovered as a by-product. Per ton of sucrose the yield is 900 lb., whereas the best yield obtained by mainland workers is 570 lb. Per ton of molasses the yield works out at about 350 lb. However, further uses have to be developed for this acid before its commercial production can be considered.—(*Int. Sugar Jr.* Vol. XL, No. 478, p. 405, 1938.)

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A Trial of Semi-Saccharate Liming.—*By R. W. G. Hessey.*

Clarification tests of eight hours' duration were carried out by the author, to compare a modification of the saccharate form of liming with ordinary cold liming. The saccharate solution (containing about 30 per cent. of the added lime in solution and the remainder in suspension) was made by introducing clarified juice to the lime mixer. From analyses of the mixed and clarified juices, neither method appeared to offer any advantage, except that the wax elimination was greater and the turbidity of the clarified juice considerably improved with the semi-saccharate method. No difference in mud characteristics was noted. The filtrability, of the shipment sugar, however, increased from 11 to 13 gallons per square foot per hour with the saccharate method, and this, together with the improved turbidity of the clarified juice suggests that the full saccharate method would give even greater improvement. This opinion of the author is in close accordance with what has been found in some other sugar producing countries.—(*Facts about Sugar*, Vol. 33, No. 8, p. 30, 1938.)

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Paper Pulp from Sugar Cane Stalks. *By C. Levi and E. Debenedetti.*

Bagasse, as obtained in a distillery using sugar cane as raw material, was treated for the production of paper, when it was found that a yield of 40 to 45 per cent. of bleachable pulp was possible by acid, alkaline and chlorination methods. It was similar to esparto.—(*Int. Sugar Jr.*, Vol. XL, No. 478, p. 405, 1938.)

TREND OF THE MARKETS.

[The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.) :—

	Foreign.	*Preferential.*
	s. d.	s. d.
3rd November	5 6	9 3
10th November	5 9	9 6
17th November	5 9¾	9 6¾
24th November	5 10½	9 7½
1st December	5 6	9 6
8th December	5 6	9 8¼
15th December	5 6	9 9
(16th December, 1937)	6 1½	9 3¾

There has recently been a very marked improvement in London terminal prices. Although this has to some extent been due to a moderate amount of speculative buying the chief reason for the sharp recovery is the changed outlook brought about by the probability that the East this year will absorb far larger quantities of Javas than appeared probable a few weeks ago, and this change in the statistical outlook has been responsible for greatly increased activity in both Raws and Refined.

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RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	Pence per lb.
26th October	8 5/16
2nd November	8 1/4
9th November	8 7/16
16th November	8 1/8
23rd November	8
30th November	7 15/16
7th December	8
14th December	8 1-16
(15th December, 1937)	7 1/4

On the 15th November the International Rubber Regulation Committee decided to increase the rubber export quota for the first quarter of 1939 from 45 per cent. to 50 per cent. of the basic allowances. The immediate reaction of the market to the news was to mark prices down below 8*d.* per lb. but some of the decline was later made good. The Committee's decision has met with approval from consuming interests but the London market was disappointed in its expection of an unchanged quota. The October consumption in the U.S.A. at 40,333 tons, represents the highest figure since September, 1937. If the rising trend in consumption continues the extra release may be justified although it is felt that the Committee would have done better to await for actually ascertained increases before making their decision.

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BANANAS.—Prices for Jamaicas are unchanged at £18 10*s.* delivered London and £18 5*s.* delivered nearest station Provinces. Brazilians have declined 10*s.* and are quoted at £15 delivered London and £16 delivered Provinces.

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association.

	American Mid.	*Egyptian Giza.*	*F.G.F. Sakel.*
28th October	5.20	8.35	8.35
4th November	5.09	8.40	8.50
11th November	5.11	8.15	8.25
18th November	5.08	8.24	8.34
25th November	5.22	8.21	8.31
2nd December	5.14	....	....
9th December	5.04	....	....
16th December	5.02	....	....
(17th December 1937)	4.81	7.21	7.94

Spinners and manufacturers have been fairly busy dealing with enquiries but sales have shown no expansion. Raw cotton prices have moved within narrow limits. The situation at the moment is extremely complicated by the policy of the U.S.A. Government. American cotton is losing ground to that grown in other countries and the spinners demand chiefly South American and Indian descriptions. There has been a better enquiry for West Indian Sea Island cotton at prices ranging from 16*d.* to 20*d.* per lb.

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COCOA.—During the past month the cocoa market has been inactive and the unsettled political and economic situation is undoubtedly playing its part to the detriment of commodity markets, but one is still looking to New York to supply eventually the stimulant which is needed, and therefore possibly, if prices of West African still go back a little, more buyers will come in. Accra cocoa is quoted at 21*s.* c.i.f. and locally $5.40 per fanega is paid for Plantation Cocoa.—(*By courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

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LIME PRODUCTS.—*Lime Oil.*—Handpressed is neglected and the nominal value is unchanged at 30*s.* per lb. The prices of Distilled are nominal and, it is stated, will remain so, until the selling pressure from countries of origin ceases. *Lime Juice.*—There is still no demand for Concentrated and Raw is unchanged at 1*s.* 9*d.* to 2*s.* 3*d.* per gallon according to quality.—(*West India Committee Circular*, 17th November, 1938.)

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COFFEE.—Supplies of new crop coffees are slow in coming forward both from Kenya and Costa Rica. Trading conditions, have, nevertheless been exceptionally slow. Quotations :—Kenyas bold size up to 81*s.* 6*d.*; second size 65*s.* London Cleaned Tanganyika bold size 64*s.* 6*d.* to 65*s.* Superior Santos 33*s.* 9*d.* cost and freight and No. 7 Rio 23*s.* 6*d.*